EFFECT OF FUELS AND FURNACE DESIGN ON SELECTIVE CATALYTIC REDUCTION SYSTEMS

Howard N. Franklin, PhD

Foster Wheeler Energy Corporation
Perryville Corporate Park
Clinton, NJ 08809-4000
908/713-2432 Phone
908/713-2405 Fax

ABSTRACT

A Selective Catalytic Reduction (SCR) discussion is presented with emphasis on fuel constituents with trace elements and furnace firing conditions that affect SCR system design. These parameters are presented for different fuels and furnace designs expanding the discussion of the impact upon SCR systems. In particular the effects of high sulfur coal in a pulverized coal boiler and the impact of a coal fired cyclone boiler are added.

INTRODUCTION

NOx reduction is required by the Clean Air Act, particularly by the November, 1990 amendments. NOx emissions are governed by Titles I, III and IV which are Ozone Attainment, Hazardous Pollutants and Acid Rain, respectively.

Previously, the author[1] presented a discussion of the impact of the fuel fired and the selection of firing system upon a Selective Catalytic Reduction system. This article relies upon the previous work for depth and references and thus only the most pertinent is included herein.

As the industry strives to reduce NOx it becomes more apparent that a keen knowledge of the boiler processes with the coal fired is required to ensure success and thus a domestic boiler manufacturer should be on any NOx reduction team

THE SCR PROCESS

The dominant SCR chemical reaction for fossil fuel firing in the presence of the catalyst is:

$$4NO + 4NH_3 + O_2 \xrightarrow{catalyst} 4N_2 + 6H_2O \quad (1)$$

In addition to the dominant NOx reduction reaction there are other side reactions which can take place: the oxidation reactions:

$$4NH_3+5O_2 \rightarrow 4NO+6H_2O \ (T \geq 850^oF=450^oC) \quad (2)$$

$$2SO_2 + O_2 \xrightarrow{catalyst} 2SO_3 \quad (3)$$

and the sulfate reactions:

$$SO_3 + 2NH_3 + H_2O \rightarrow (NH_4)_2SO_4 \quad (4)$$

$$SO_3 + NH_3 + H_2O \rightarrow NH_4HSO_4 \quad (5)$$

These reactions are discussed in more detail in the reference.

FUEL ASSESSMENT

Sensitivity of the SCR system to the fuel elements is discussed in the reference. Table 1 lists three coals submitted for SCR proposal or review. Table 2 shows the flue gas constituents of these fuels after combustion.

Flyash

The coal probably will require 7.5 mm honeycomb pitch although “equivalent service” with a smaller pitch would be considered. Plate pitches would similarly be evaluated.

Oxygen

The cyclone boiler flue gas has low oxygen content. This will necessitate a small compensating increase in catalyst volume relative to the other fuels and their firing methods.

Inlet NOx

The high levels of inlet NOx preclude concern.

Moisture

No high levels of moisture are found in the boilers.

Chlorine

The cyclone unit has chlorine. An assessment of a possible ammonium chloride plume is required. Most likely additional spare catalyst room would be

recommended in the SCR reactor to allow for further ammonia slip reduction should plume occur.

Sulfur

The high levels of sulfur in the form of SO_2 for the coals require careful consideration.

Low oxidation catalyst, possible low load economizer bypass and sootblowing must be considered as well as an air preheater designed to minimize plugging.

Alkaline Metals

The concentration of sodium in the fuels is sufficiently low that it would play no significant role in the design of the SCRs. Although this was expected it is not always the case.

Arsenic

The arsenic is a problem for the coal fired cyclone boiler. A special catalyst formulation would have to be required and it is expected that the catalyst life guarantees from suppliers will shorten; probably on the order of two (2) years rather than the normally offered three (3) years for the other coal fired boilers shown.

Vanadium

The vanadium was found to be of insufficient concentration to pose problems.

CONCLUSIONS

Although there are many aspects to designing a SCR for a particular fuel and furnace, these can be addressed to achieve an efficient and reliable coal fired SCR design.

For SCR retrofit applications the selection of fuel and its method of firing significantly affects the SCR system design. The SCR designer needs to have ready and easy access to boiler manufacturing knowledge; arch, wall, tangential, cyclone, etc. for the guidance and experience required to achieve success. Such experience, especially with the variety of domestic coals being fired today, is essential to understand all the appropriate boiler impacts.

REFERENCES

1. Franklin, H. N., 1996 “The Effect of Fuel Properties and Characteristics on Selective Catalytic Reduction Systems”, Proceeding of the 1996 International Joint Power Generation Conference, Vol. 1, pp 421-428.

TABLE 1: FUEL ANALYSES

Constituent	P. C. Boiler	P. C. Boiler	Cyclone Boiler
	Coal	Coal	Coal
	Wt. %	Wt. %	Wt. %
N_2	1.38	1.14	0.70
C	68.72	68.12	49.26
H_2O	6.00	6.25	29.16
O_2	6.64	6.33	11.99
H_2	4.53	4.91	3.43
S	0.65	4.25	0.38
Cl	-	-	0.02
Trace Elements	As	Na, V	As, V, Ca
Ash	12.08	9.00	5.06

TABLE 2: FLUE GAS ANALYSES

	P. C. Boiler	P. C. Boiler	Cyclone Boiler
Constituent	Coal	Coal	Coal
Excess Air, %	20	18	10
Volume %			
O_2	3.28	2.99	1.67
N_2	73.39	73.17	68.45
H_2O	8.31	8.88	14.15
CO_2	14.08	13.74	14.85
SO_2	0.05	0.33	0.049
Ar	0.89	0.89	0.83
Cl_2	0.00	0.00	0.001
Inlet NOx, ppmvd	325	339	1,190
Mol. Wt.	29.68	29.67	29.16
Trace Elements	As	V, Na,	As, V, Na,
Flyash	High	High	Low*
*Cyclone ash size distribution is smaller than Pulverizer ash			